AMENDMENTS TO THE CLAIMS

1. (Currently amended) A waveguide-type optical device comprising:

a substrate ~~on~~ in which optical waveguides or optical fibers are provided, and a ~~linear~~ trench in the substrate cutting across the optical waveguides or the optical fibers ~~to divide each~~ for dividing the optical paths of the optical waveguides or the optical fibers ~~into two portions~~;

a pair of transparent electrodes assigned to each optical waveguide or optical fiber and formed ~~in a direction substantially perpendicular to the longitudinal direction~~ on the substrate, one electrode on each side of the trench and extending from the surface of the substrate at ~~both sides~~ each side of the trench ~~to~~ onto the respective wall ~~surfaces~~ surface of the trench; and

a material or ~~a surface-normal optical~~ device filled or inserted into the trench, and which has one of an electro-optic effect, a thermo-optic effect, a light emitting function, a light receiving function, and a light modulating function, wherein light emitted from one of the divided portions of each of the optical waveguides or the optical fibers goes ~~straight~~ through the transparent electrode to the material or the ~~surface-normal optical~~ device ~~and is incident on the other of the divided portions~~.

2. (Currently amended) A waveguide-type optical device as claimed in claim 1, wherein the electrodes are part of a flexible substrate which lies on a member of an anisotrope rubber on the surface of the device substrate ~~are extended by attaching a flexible substrate or by wire bonding~~, and a voltage is applied to the material or device via the ~~extended~~ electrodes.

3. (Currently amended) A waveguide-type optical device ~~as claimed in claim 1,~~ comprising:

a substrate on which optical waveguides or optical fibers are provided and a linear trench cutting across the optical waveguides or the optical fibers to divide each of the optical waveguides or the optical fibers into two portions;

a pair of electrodes assigned to each optical waveguide or optical fiber and formed in a direction substantially perpendicular to the longitudinal direction of the trench, from the surface of the substrate at both sides of the trench to wall surfaces of the trench;

a material or a surface-normal optical device filled or inserted into the trench, and which has one of an electro-optic effect, a thermo-optic effect, a light emitting function, a light receiving function, and a light modulating function, wherein light emitted from one of the divided portions of each of the optical waveguides or the optical fibers passes through the material or the surface-normal optical device and is incident on the other of the divided portions; and

wherein the material or device which is filled or inserted into the trench is one of a nematic liquid crystal having an electro-optic effect, a cholesteric-nematic phase transition type liquid crystal, a polymer network liquid crystal, a polymer-dispersed liquid crystal, a polymer-stabilized liquid crystal, a dynamic scattering liquid crystal, and a ferroelectric liquid crystal.

4. (Currently amended) A waveguide-type optical device as claimed in claim ~~1~~ 3, wherein the material or device ~~which is~~ filled or inserted into the trench is a polymeric material having a thermo-optic effect.

5. (Currently amended) A waveguide-type optical device as claimed in claim 1, wherein the material or device ~~which is~~ filled or inserted into the trench is arranged perpendicularly to the propagation direction of the light for forming one of a surface-normal optical modulator, a surface light emitting device, and a surface-normal detector which has one of a light emitting function, a light receiving function, and a light modulating function.

6. (Currently amended) A waveguide-type optical device as claimed in claim 3, wherein:

the material or device which is filled or inserted into the trench is ~~the~~ a polymer-dispersed liquid crystal~~; and~~

~~the polymer-dispersed liquid crystal~~ which is one of a normal polymer-dispersed liquid crystal in which each particle has a diameter of 0.5 μm or more, and a nanosize droplet liquid crystal in which each particle has a diameter of 150 nm or less.

7. (Currently amended) A manufacturing method of a waveguide-type optical device, comprising the steps of:

forming a linear trench on a substrate ~~on~~ in which optical waveguides or optical fibers are provided, in a manner such that the trench ~~cuts across~~ divides the optical waveguides or the optical fibers ~~to divide each of the optical waveguides or the optical fibers~~ into two portions;

forming a pair of electrodes~~, which is~~ assigned to each optical waveguide or optical fiber, each electrode of a pair being on one side of the trench in a direction substantially perpendicular to the longitudinal direction of the trench, and extending from the surface of the substrate at both sides of the trench ~~to~~ and the respective wall surfaces of the trench; and

filling or inserting a material or a surface-normal optical device into the trench, which has one of an electro-optic effect, a thermo-optic effect, a light emitting function, a light receiving function, and a light modulating function, wherein light emitted from one of the divided portions of each of the optical waveguides or the optical fibers ~~goes straight~~ passes through the material or the surface-normal optical device and is incident on the other of the divided portions.

8. (Original) A manufacturing method as claimed in claim 7, wherein the electrodes are formed by sputtering or vapor deposition.

9. (Currently amended) A ~~manufacturing~~ method ~~as claimed in claim 7,~~ of manufacturing a waveguide-type optical device, comprising the steps of:

forming a linear trench on a substrate on which optical waveguides or optical fibers are provided, in a manner such that the trench cuts across the optical waveguides or the optical fibers to divide each of the optical waveguides or the optical fibers into two portions;

forming a pair of electrodes, which is assigned to each optical waveguide or optical fiber, in a direction substantially perpendicular to the longitudinal direction of the trench, from the surface of the substrate at both sides of the trench to wall surfaces of the trench; and

filling or inserting a material or a surface-normal optical device into the trench, which has one of an electro-optic effect, a thermo-optic effect, a light emitting function, a light receiving function, and a light modulating function, wherein light emitted from one of the divided portions of each of the optical waveguides or the optical fibers goes straight through the material or the surface-normal optical device and is incident on the other of the divided portions;

wherein the step of forming a pair of electrodes includes:

inserting a polymer material into the trench and selectively removing a portion of the polymer material; and

performing patterning of said pair of electrodes, which is ~~separately~~ assigned to each optical waveguide or optical fiber, on the wall surfaces of the trench by etching.

10. (Currently amended) A manufacturing method as claimed in claim ~~7~~ 9, wherein the step of forming a pair of electrodes includes:

patterning the electrodes on the wall surfaces of the trench by directly using a laser beam.

11. (Currently amended) A method of manufacturing ~~method as claimed in claim 7,~~ a waveguide-type optical device, comprising the steps of:

forming a linear trench on a substrate on which optical waveguides or optical fibers are provided, in a manner such that the trench cuts across the optical waveguides or the optical fibers to divide each of the optical waveguides or the optical fibers into two portions;

forming a pair of electrodes, which is assigned to each optical waveguide or optical fiber, in a direction substantially perpendicular to the longitudinal direction of the trench, from the surface of the substrate at both sides of the trench to wall surfaces of the trench; and

filling a material into the trench, which has one of an electro-optic effect, a thermo-optic effect, a light emitting function, a light receiving function, and a light modulating function, wherein light emitted from one of the divided portions of each of the optical waveguides or the optical fibers goes straight through the material or the surface-normal optical device and is incident on the other of the divided portions;

wherein a liquid crystal is filled into the trench, and the filling step includes:

coating each wall surface of the trench with an alignment layer for the liquid crystal;

~~performing~~ rubbing ~~of~~ the alignment layer by inserting a tape and pulling the tape in a single direction;

filling a polymer-stabilized liquid crystal into the trench; and

performing alignment of the liquid crystal by irradiation of ultraviolet light while a magnetic field is applied to the liquid crystal.

12. (Currently amended) A method of manufacturing ~~method as claimed in claim 7,~~ a waveguide-type optical device comprising the steps of:

forming a linear trench on a substrate on which optical waveguides or optical fibers are provided, in a manner such that the trench cuts across the optical waveguides or the optical fibers to divide each of the optical waveguides or the optical fibers into two portions;

forming a pair of electrodes, which is assigned to each optical waveguide or optical fiber, in a direction substantially perpendicular to the longitudinal direction of the trench, from the surface of the substrate at both sides of the trench to wall surfaces of the trench; and

filling a material into the trench, which has one of an electro-optic effect, a thermo-optic effect, a light emitting function, a light receiving function, and a light modulating function, wherein light emitted from one of the divided portions of each of the optical waveguides or the optical fibers goes straight through the material or the surface-normal optical device and is incident on the other of the divided portions;

wherein a liquid crystal is filled into the trench, and the filling step ~~includes~~ comprises:

coating each wall surface of the trench with a photo-alignment layer for the liquid crystal; and

performing alignment of the liquid crystal by irradiating the photo-alignment layer with first and second polarized ultraviolet light beams.

13. (Currently amended) A method of manufacturing ~~method as claimed in claim 7,~~ a waveguide-type optical device comprising the steps of:

forming a linear trench on a substrate on which optical waveguides or optical fibers are provided, in a manner such that the trench cuts across the optical waveguides or the optical fibers to divide each of the optical waveguides or the optical fibers into two portions;

forming a pair of electrodes, which is assigned to each optical waveguide or optical fiber, in a direction substantially perpendicular to the longitudinal direction of the trench, from the surface of the substrate at both sides of the trench to wall surfaces of the trench; and

filling or inserting a material or a surface-normal optical device into the trench, which has one of an electro-optic effect, a thermo-optic effect, a light emitting function, a light receiving function, and a light modulating function, wherein light emitted from one of the divided portions of each of the optical waveguides or the optical fibers goes straight through the material or the surface-normal optical device and is incident on the other of the divided portions;

wherein a liquid crystal is filled into the trench, and the filling step ~~includes~~ comprises:

coating each wall surface of the trench with an alignment layer for the liquid crystal; and

performing alignment of the liquid crystal by irradiating the alignment layer with an ion beam.

14. (Currently amended) A waveguide-type optical device comprising:

a substrate on which optical waveguides or optical fibers are provided and a ~~linear~~ trench cutting across the optical waveguides or the optical fibers to divide each of the optical waveguides or the optical fibers into two portions;

a surface-normal active optical device driven by an applied voltage, which is substantially vertically inserted into the trench and is fixed in the trench; and

a support member attached to a portion of the surface-normal active optical device ~~so as~~ to support the surface-normal active optical device when inserting the surface-normal active optical device into the trench, wherein the portion of the surface normal device that is not inserted into the trench ~~and the surface normal active optical device~~ is supported by the support member ~~on the substrate~~,

wherein light emitted from one of the divided portions of each of the optical waveguides or the optical fibers ~~goes straight~~ passes through the surface-normal active optical device and is incident on the other of the divided portions.

15. (Currently amended) A waveguide-type optical device as claimed in claim 14, wherein for a given thickness w of the surface-normal active optical device, and width W of the trench satisfies the condition "w<W<300 μm".

16. (Previously presented) A waveguide-type optical device as claimed in claim 14, wherein electrodes are formed on the support member, which function as electrodes of the surface-normal active optical device.

17. (Currently amended) A waveguide-type optical device as claimed in claim 14, wherein:

the support member is one of a rectangular block, an L-shaped block, and a cylindrical block, and the block is made of one of glass, ~~ceramics~~ a ceramic, and ~~plastics~~ a plastic; and

the height h and width I of the block, and length s of a protruding portion of the surface-normal active optical device, which protrudes from the block, have a relationship

of "I/h>s/I" by which the surface-normal active optical device does not fall when the device supported by the support member is put on the surface of the substrate in an inclined position.

18. (Currently amended) A waveguide-type optical device as claimed in claim 16, wherein:

the surface-normal active optical device has electrodes;

the support member is a rectangular block, and L-shaped electrodes are formed on the block in a manner such that the L-shaped electrodes lie on two adjacent faces of the block, where the faces include the top face of the block; and

the electrodes of the surface-normal active optical device are respectively connected to the electrodes of the block attached to the device, thereby extending the electrodes of the device to the top face of the block.

19. (Currently amended) A waveguide-type optical device as claimed in claim 14, wherein the surface-normal active optical device is one of:

a PbS optical detector formed on a glass plate or an a-Si (amorphous silicon) optical detector;

an optical detector obtained by thinning a semiconductor device;

a semiconductor optical modulator;

a polarizer obtained by dispersing metal particles in glass, where the particles are aligned in the long particle axis;

a wavelength plate made of an optical crystal;

a dielectric multi-layered filter deposited on a glass plate;

an ND (neutral density) filter;

a variable-wavelength filter made by placing an electro-optic crystal or electro-optic ~~ceramics~~ ceramic between dielectric multi-layered mirrors; and

a polarization modulator having an electro-optic crystal or electro-optic ~~ceramics~~ ceramic.

20. (Currently amended) A waveguide-type optical device as claimed in claim 14, wherein:

the surface-normal active optical device is a liquid crystal device; and

the support member is a pair of blocks between which the liquid crystal device is placed,

wherein the liquid crystal device comprises:

glass plates which are respectively attached to faces of the blocks, where said faces of the blocks face each other via the liquid crystal device and a patterned electrode is formed on each glass plate;

an alignment layer formed on each glass plate, where the alignment layer is subjected to an alignment process such as rubbing; and

a liquid crystal filled into a space between the alignment layers of the glass plates.

21. (Original) A waveguide-type optical device as claimed in claim 20, wherein:

the patterned electrode includes 8 electrodes having a radial and symmetric form with respect to a center portion surrounded by the 8 electrodes;

said center portion has a window having a diameter of 20 to 50 μm;

voltage applied to each of the 8 electrodes is controlled so as to apply an electric field, which has any desired power and is in any desired direction, to the center portion surrounded by the 8 electrodes; and

incident light having any polarization direction is converted into light having any desired polarization direction.

22. (Previously presented) A waveguide-type optical device as claimed in claim 14, wherein:

the surface-normal active optical device is an optical modulator which comprises:

a PLZT plate having four trenches dug from upper, lower, right, and left sides of the plate;

four electrodes formed from the above four sides of the PLZT plate to the inside of each trench;

a conductive adhesive with which each trench is filled; and

a glass plate attached to the PLZT plate, which has four electrodes to which the four electrodes of the PLZT plate are respectively connected, and

wherein the glass plate is attached and fixed to the support member in a manner such that light passes through a center portion between the four electrodes of the PLZT plate, and the electrodes of the glass plate function as external electrodes of the optical modulator; and

voltage applied to each of the four electrodes is controlled so as to apply an electric field having any desired power and in any desired direction, thereby continuously and completely controlling the polarization direction of incident light into light having a linear polarization.

23. (Original) A waveguide-type optical device as claimed in claim 22, wherein the optical waveguides or optical fibers which are provided on the substrate are expanded core fibers.

24. (Previously presented) A manufacturing method of a waveguide-type optical device, comprising the steps of:

forming a linear trench on a substrate on which optical waveguides or optical fibers are provided, in a manner such that the trench cuts across the optical waveguides or the optical fibers to divide each of the optical waveguides or the optical fibers into two portions;

attaching a support member to a surface-normal active optical device which is driven by an applied voltage, in a manner such that a portion of the active optical device protrudes from the support member; and

substantially vertically inserting the protruding portion of the surface-normal active optical device which is supported by the supported member into the trench and fixing the device in the trench.

25. (Previously presented) A manufacturing method as claimed in claim 24, wherein for a given thickness w of the surface-normal active optical device, width W of the trench satisfies the condition "$w<W<300\ \mu m$".

26. (Previously presented) A manufacturing method as claimed in claim 24, wherein:

a positioning mark is provided on the surface-normal active optical device before the device is inserted into the trench to make a portion of the surface-normal active optical device, through which light passes, coincide with a corresponding core of each

optical waveguide or optical fiber, where the position of the positioning mark is away from the position of the portion through which light passes, by the distance from the surface of the substrate to the position of the core; and

the support member is attached to the surface-normal active optical device in a manner such that the positioning mark coincides with the bottom face of the support member.

27. (Previously presented) A manufacturing method as claimed in claim 24, wherein:

the support member is one of a rectangular block, an L-shaped block, and a cylindrical block, and the block is made of one of glass, ceramics, and plastics; and

height h and width I of the block, and length s of a protruding portion of the surface-normal active optical device, which protrudes from the block, have a relationship of "I/h>s/I"; and

the step of inserting the protruding portion of the surface-normal active optical device includes the steps of:

putting the device supported by the support member on the surface of the substrate in an inclined position, so as to prevent the device from falling onto the substrate;

sliding the device on the surface of the substrate towards the trench; and

making the device fall into the trench and fixing the inserted device.

28. (Previously presented) A manufacturing method as claimed in claim 27, wherein in the step of sliding the device on the surface of the substrate, both the support member and an end of the surface-normal active optical device contact the surface of the substrate.

29. (Previously presented) A manufacturing method as claimed in claim 27, wherein in the step of making the device fall into the trench, when the surface-normal active optical device reaches the position of the trench, an end of the device contacts a wall surface of the trench and the surface-normal optical device bends and falls into the trench.

30. (Previously presented) A manufacturing method as claimed in claim 24, wherein:

the surface-normal active optical device has electrodes; and

the support member is a rectangular block,

the method further comprising the steps of:

forming L-shaped electrodes on the block in a manner such that the L-shaped electrodes lie on two adjacent faces of the block, where the faces include the top face of the block; and

respectively connecting the electrodes of the surface-normal active optical device to the electrodes of the block attached to the device, thereby extending the electrodes of the device to the top face of the block.

31. (Currently amended) A waveguide-type optical device ~~as claimed in claim 1,~~ comprising:

a substrate on which optical waveguides or optical fibers are provided and a linear trench cutting across the optical waveguides or the optical fibers to divide each of the optical waveguides or the optical fibers into two portions;

a pair of electrodes assigned to each optical waveguide or optical fiber and formed in a direction substantially perpendicular to the longitudinal direction of the trench, from the surface of the substrate at both sides of the trench to wall surfaces of the trench; and

a material or a surface-normal optical device filled or inserted into the trench, and which has one of an electro-optic effect, a thermo-optic effect, a light emitting function, a light receiving function, and a light modulating function, wherein light emitted from one of the divided portions of each of the optical waveguides or the optical fibers goes straight through the material or the surface-normal optical device and is incident on the other of the divided portions;

wherein the width of the trench is equal to or less than 300 μm.

32. (Currently amended) A ~~manufacturing~~ method ~~as claimed in claim 7,~~ of manufacturing a waveguide-type optical device comprising the steps of:

forming a linear trench on a substrate on which optical waveguides or optical fibers are provided, in a manner such that the trench cuts across the optical waveguides or the optical fibers to divide each of the optical waveguides or the optical fibers into two portions;

forming a pair of electrodes, which is assigned to each optical waveguide or optical fiber, in a direction substantially perpendicular to the longitudinal direction of the trench, from the surface of the substrate at both sides of the trench to wall surfaces of the trench; and

filling or inserting a material or a surface-normal optical device into the trench, which has one of an electro-optic effect, a thermo-optic effect, a light emitting function, a light receiving function, and a light modulating function, wherein light emitted from one of the divided portions of each of the optical waveguides or the optical fibers passes straight through the material or the surface-normal optical device and is incident on the other of the divided portions;

wherein the width of the trench is equal to or less than 300 μm.

33. (Previously presented) A waveguide-type optical device as claimed in claim 14, wherein the optical waveguides or optical fibers provided on the substrate are expanded core fibers.